

Modification of the Stratification and Velocity Profile within the Straits and Seas of the Indonesian Archipelago

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LONG-TERM GOALS

To improve our understanding of the energetic ocean physical processes within the northeastern Indonesian seas, as needed to improve our simulation of the regional circulation and mixing patterns.

OBJECTIVES

The gap in understanding basic ocean physics of the Indonesian seas is most acute in the northeastern seas: the Halmahera Sea, Maluku Sea, the Seram Sea and the northern Banda Sea (Spice Islands). Besides the monsoonal forcing there is an abundance of intraseasonal features of varied scales, derived from: the energetic Pacific western boundary currents that project into the region way of the Mindanao and Halmahera Retroflexions (Eddies); localized winds blowing through the gaps between the islands composing the “Spice Island” configuration, inducing submesoscale clockwise and counterclockwise wind stress structures; strong tidal currents amidst the array of small seas and narrow passages. These factors make for a vigorous turbulent environment, one that is poorly understood, yet it is necessary to develop a quantitative grasp of the associated small scale ocean processes to properly model the regional circulation, and its role in the climate and marine ecosystems. The objective of N00014-10-1-0317 was to develop and present this theme to our Indonesian colleagues, with the intention of developing a field activity in the Spice Island region.

APPROACH

Use existing observational data sets and model output to produce an overview of the ocean circulation and mixing within the northeastern Indonesia seas; to identify gaps in our understanding that hinder quantitative grasp of the regional oceanography; and to develop plans for an exploratory research cruise into the Spice Island region to obtain some basic parameters of the circulation/mixing environment. A.L.Gordon and A.Ffield pursued topic in a lecture tour in Indonesian in July/August 2010; and by A.L.Gordon discussions with Indonesian colleagues and lectures in Jakarta in March 2012 and June 2012.

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WORK COMPLETED

The 3rd year saw these activities: In March 2012, A.L.Gordon attended a CLIVAR Task team on the ITF, at Ancol, Indonesia. A program called GATEWAY was discussed with Indonesian and Korean colleagues. The Gateway objective is to investigate the tropical Pacific flow into the ITF.

In June 2012 A.L.Gordon presented a lecture at the Seminar on the Science of the Halmahera Sea, entitled: “Oceanography of the Indonesian Seas; the Challenge of the (spicy) Halmahera and Seram Seas”. This included the following topics:

Pacific Ocean Entry Portals:

- South China Sea via Luzon Strait to Karimata and Sibutu;
- Tropical Pacific via Mindanao & Halmahera Retroflexions

Indian Ocean Exit Portals:

Sunda Archipelago passages:
Lombok, Ombai, Timor,
[Sunda Strait, Malacca Strait]

Interior Seas, the mix-master (outflow differs from inflow):

Makassar Strait: western boundary,
primary inflow pathway;
Eastern seas: Banda ‘cyclonic gyre’,
Seram/Halmahera/Maluku Seas puzzle

RESULTS

[see the year 2 annual report for more complete results, as year 3, reported here is a non-funds extension, to present summary results at 2 meetings in Indonesia, March 2012, June 2012.]

The gap in understanding basic ocean physics of the Indonesian seas is most acute in the northeastern seas (figure 1), Spice Island domain: the Halmahera Sea, Maluku Sea, and the Seram Sea.

- These seas are exposed to the energetic Pacific western boundary currents that project into the region by way of the Mindanao and Halmahera Retroflexions;
- Wind blowing through the gaps between the islands generate energetic sub-mesoscale eddies;
- The complex submarine topography coupled with the strong tidal action and wind induced eddies lead to a vigorous turbulent environment;

It is necessary to develop a quantitative grasp of the ocean processes to properly model the regional circulation, and its role in the climate and marine ecosystems, including supporting the diversity of the Coral Triangle marine ecosystem.

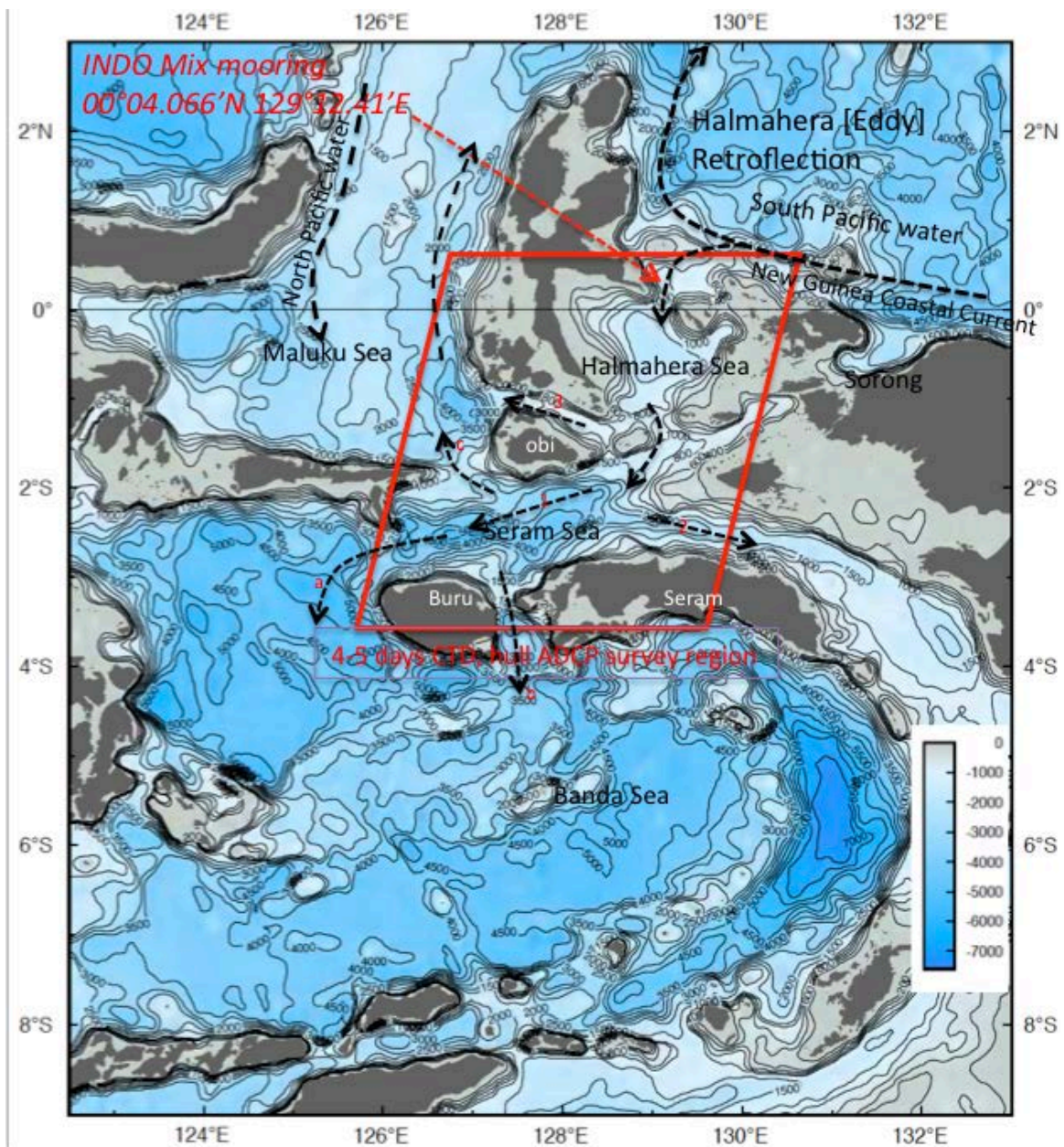


Figure 1. The Region. South Pacific water passes into the northern Halmahera Sea over the 580 m sill (Gordon et al. 2003; near the position of the 650 m deep French IndoMix mooring to be recovered by this proposed program), splitting off from the New Guinea Coastal Current, a component of the Halmahera Retroflection (“Retroflection” is more proper than “Eddy” often used to identify this feature) . The southern exit is more complex and highly time variable (inference from HYCOM). Three paths are likely: 1: south of Obi, westward into the region of the western Seram Sea north of Buru, from which the flow may follow three paths (a,b,c); 2: eastward along the northern coast of Seram, into the eastern arc of the Indonesian Seas; 3: Within the narrow channel north of Obi towards the Maluku Sea. While Arlindo 1993/94 data (Ilahude and Gordon, 1996) suggests that the Maluku (North Pacific) and Halmahera (South Pacific) inflow mainly returns to the Pacific in the eastern Maluku, with some leakage (La Nina?) into the Banda Sea around Buru Island is likely. It is also likely that some Halmahera Seas inflow may follow the eastern arc of the Indonesian seas to the Timor Passage and Indian Ocean.

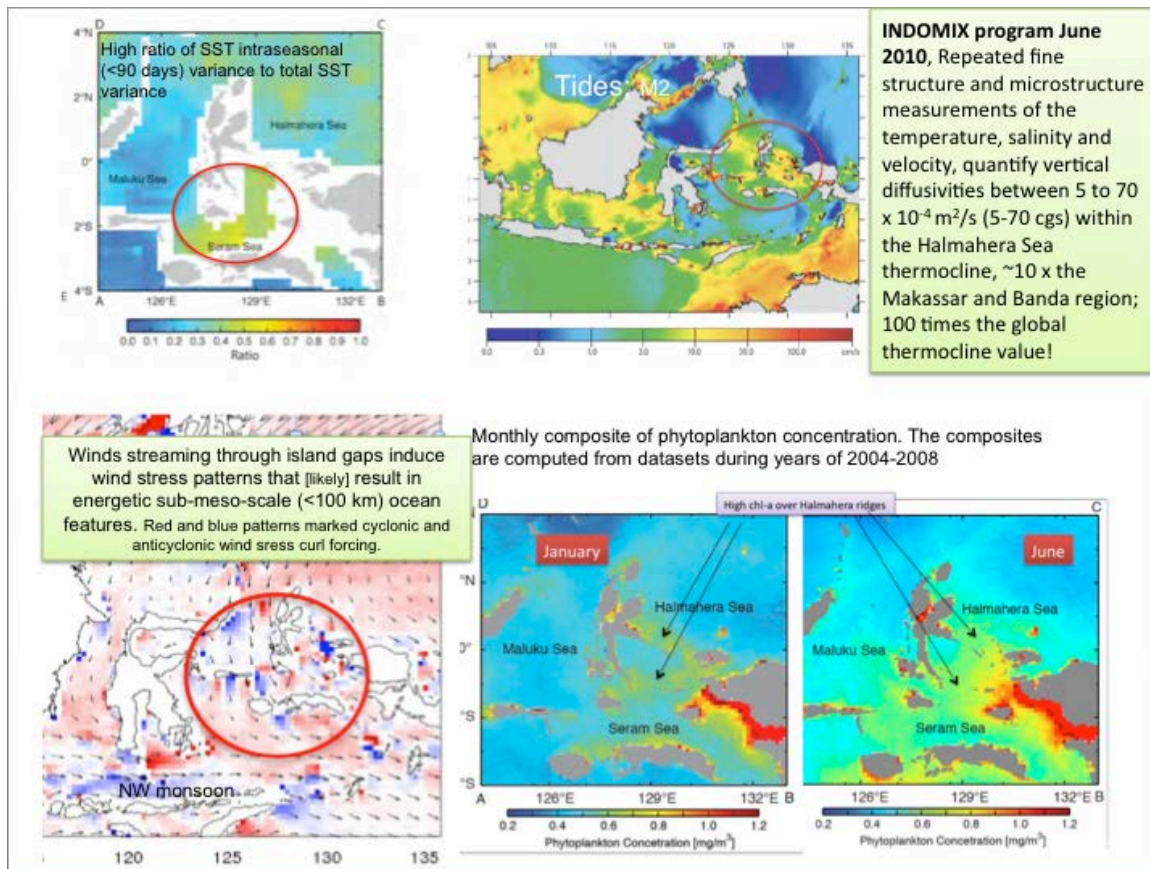


Figure 2: Features of the Spice Islands: upper left: intraseasonal SST signal; upper right: Tides, M2; lower left: wind stress curl; lower right: chl-a.

The intraseasonal SST events may be related to the Madden Julian Oscillation passing over the Indonesia seas. The survival of MJO as they move across the Indonesian seas towards the Pacific Ocean may be coupled to the SST intraseasonal fluctuations within the Indonesia seas, and may act to link the Indian Ocean Dipole (IOD) to ENSO [?] . As part of this program the study was prepared to relate MJO to the IOD. The study: Wilson, E.,A. et al., in press JGR-Atmosphere (minor revision shave been made); abstract:

The characteristics of Madden Julian Oscillation (MJO) development and propagation during Indian Ocean Dipole (IOD) events are presented in this study. We find that MJO activity over the Indian Ocean and Maritime Continent is enhanced during negative IOD and subdued during positive IOD. MJO events occurring during positive IOD have weaker convection and less organized wind anomalies than those occurring during neutral or negative IOD. These differences are starkest over the eastern Indian Ocean, where the IOD has the greatest effect on low level humidity. For this reason, we posit that the IOD primarily influences the MJO through its modulation of local low-level moisture. This notion is supported by several MJO theories, specifically those that emphasize the importance of low-level moisture convergence.

The Spice Island domain lies at the center of the Coral Triangle (Figure 3; <http://www.coraltrianglecentre.org/en/page/about-ctc>)

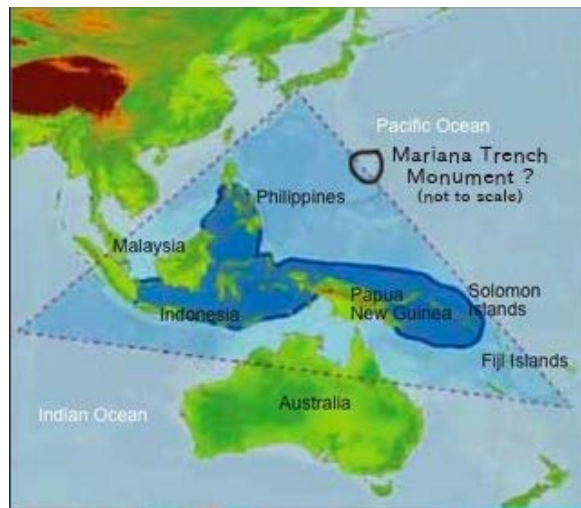


Figure 3. *The Coral Triangle is a region , covering over 6 million square kilometers that holds the greatest number of corals, sponges, crustaceans, mollusks and fish on this planet. There are over 600 types of coral, 3000 species of fish, sea turtles, whales, and dolphins. It is now known as the global center for marine diversity.*

Summary: The water-ways SE Asia Seas offer an oceanographic challenge to both observational and model research for investigation of regional circulation, which responds to: strong monsoonal winds, textured by mountainous islands; strong tides, complex ocean bottom morphology of isolated deep basins within a network of interconnecting straits. *While there has been great progress in the last decades, there remain many unknowns, particularly in the puzzling NE seas of the Spice Island region.*

IMPACT/APPLICATIONS

The program has direct applications for the development of a quantitative and coordinated field program for Indonesia and its international partners, in the relatively unknown northeastern seas of Indonesia.

TRANSITIONS

None

RELATED PROJECTS

None

REFERENCES

PUBLICATIONS

Wilson, E.,A. A.L. Gordon, D. Kim Effects of the Indian Ocean Dipole on Madden Julian events, *in press JGR-Atmosphere*

PATENTS

None